Hydrostatic Testing Symposium

Michelle Cooke

Interim Deputy Executive Director for Safety

California Public Utilities Commission

May 06, 2011

Context and Introduction

- PG&E has committed to conduct hydrostatic pipeline pressure testing on over 150 miles of its natural gas transmission pipeline network in California in 2011
- The pipeline segments to be tested have characteristics similar to those of the section that ruptured in San Bruno
- Hydrostatic testing of natural gas pipelines on this scale in the intended timeframe is unique and has raised public awareness, interest and concern

Symposium Objectives

- Provide a practical understanding of hydrostatic testing, what it is and what you can learn from it
- Learn from another regulatory agency with pipeline safety and hydrostatic testing oversight
- Receive an overview of PG&E’s testing program
- Understand what the public can expect when hydrostatic testing occurs in their neighborhood
- Understand perspectives from the Commission and the public

Agenda

Topic	Lead	Time
Kick-off & Symposium Overview	Cooke	10:00
Opening Thoughts	Commissioners	10:10
Overview of Hydrostatic Testing	Kiefner	10:20
Questions from Commissioners	Commissioners	10:40
Perspective from Office of State Fire Marshall	Gorham	10:50
Details of PG&E’s Testing Program	Campbell	11:00
Analysis of PG&E’s Hydrostatic Testing Program	Shori	11:15
Questions from Commissioners	Commissioners	11:25
What can the Public Expect	Brown	11:35
Questions From the Public	Cooke	11:45

Commissioner Mark Ferron

Commissioner Mike Florio

Commissioner Timothy A. Simon

OPENING THOUGHTS

John Kiefner, Ph.D, P.E.

Kiefner & Associates

OVERVIEW OF HYDROSTATIC TESTING

OVERVIEW OF HYDROSTATIC TESTING

A Presentation to the

California Public Utilities Commission

May 6, 2011

By

John F. Kiefner, Ph.D, P.E.

Kiefner and Associates, Inc.

Pipeline Safety

- Pipelines function efficiently by transporting fluids under pressure.
- Internal pressure is the most significant source of stress on a pipeline
- The maximum operating pressure and the diameter of a pipeline are usually chosen to meet gas, crude oil, or refined product delivery requirements
- Pipelines are designed to have sufficient strength and wall thickness to safely withstand the design maximum operating pressure
- For a pipeline to be operated safely, it is necessary to assure that the pipe is free of injurious defects that could impair its pressure-carrying capacity
- A pipeline's integrity is a measure of its ability to operate safely
- A hydrostatic test is an effective tool for establishing a high degree of pipeline integrity

Why conduct a hydrostatic test of a pipeline?

- To validate the ability of the pipeline to operate safely at its maximum operating pressure
- To remove or prove the absence of flaws that could cause the pipeline to rupture at its maximum operating pressure
- To establish a predictable margin of safety against failure at the maximum operating pressure
- To assure a minimum period of safe operating life
- To revalidate the integrity of an existing pipeline when there is reason to doubt its ability to operate safely at its maximum operating pressure

How does a hydrostatic test validate the safety of a pipeline?

- The pressure during a hydrostatic test is raised to a level significantly above the maximum operating pressure of the pipeline (usually 1.25 to 1.5 times the maximum operating pressure)
- Any flaws that survive the test are too small to fail at the maximum operating pressure
- The ratio of test pressure to operating pressure establishes the margin of safety
- The higher the ratio, the greater the assurance of safety

Are there alternatives to hydrostatic testing that can be used to validate pipeline integrity?

- In-line inspection tools (smart pigs) can be run through some pipelines to validate some aspects of pipeline integrity
- Smart pigs are very good tools for finding and characterizing corrosion-caused metal loss
- Smart pigs can be used to locate dents and mechanical damage
- Smart pigs can find and characterize some types of cracks
- Usually, more than one type of smart pig must be used to find and characterize all possible integrity threats
- Smart pigs are of no value, however, if the pipeline is not able to accommodate the passage of the tools
- Sharp bends, diameter restrictions, and lack of launching and receiving facilities in some older pipelines prevent the use of smart pigs
- Hydrostatic testing is the only alternative in such cases

Benefits Of Hydrostatic Testing

- Positive demonstration of pressure-carrying capacity
- Applicable to all pipelines
- Reliable margin of safety established for a predictable period of time
- Applicable to any kind of longitudinally oriented defect

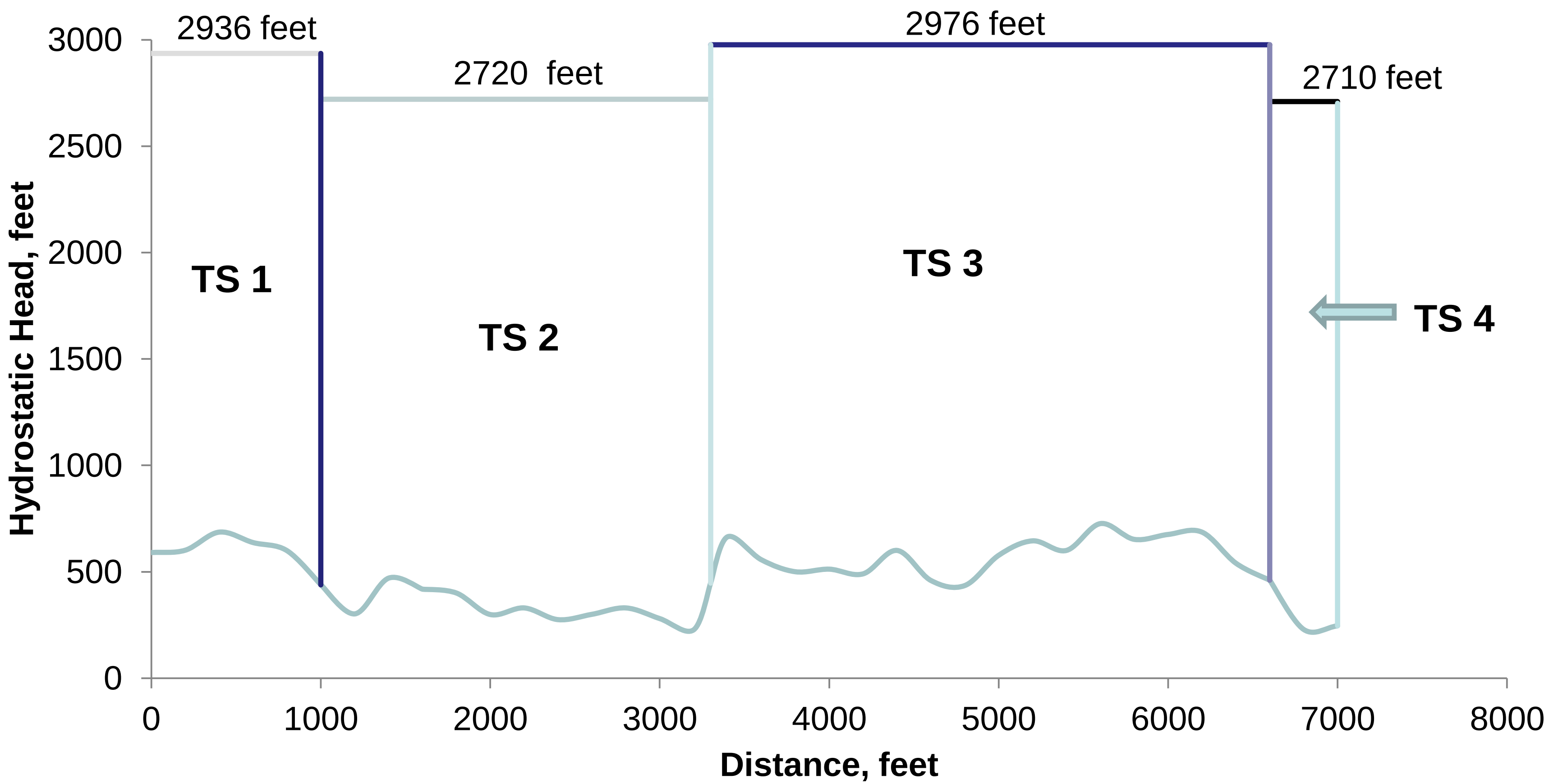
Limitations Of Hydrostatic Testing

- Very costly
- Pipeline must be out of service for a period of time
- Time out of service hard to predict
- Water acquisition and disposal costs and problems
- Water hard to remove entirely
- Defects too small to fail remain unidentified and may grow to failure later

How do you conduct a hydrostatic test of an existing pipeline?

- Take the pipeline out of service
- Fill it with water
- Pressurize the water to the desired pressure level (usually 1.25 to 1.5 times the maximum operating pressure)
- Hold the pressure for the required amount of time to detect leaks (usually 8 hours)
- Release the pressure
- Remove the water from the pipeline as completely as possible
- Return the pipeline to service

Hydrostatic test design



To account for pressure differences caused by hydrostatic head, test segments must be separated when pipeline elevation changes are significant

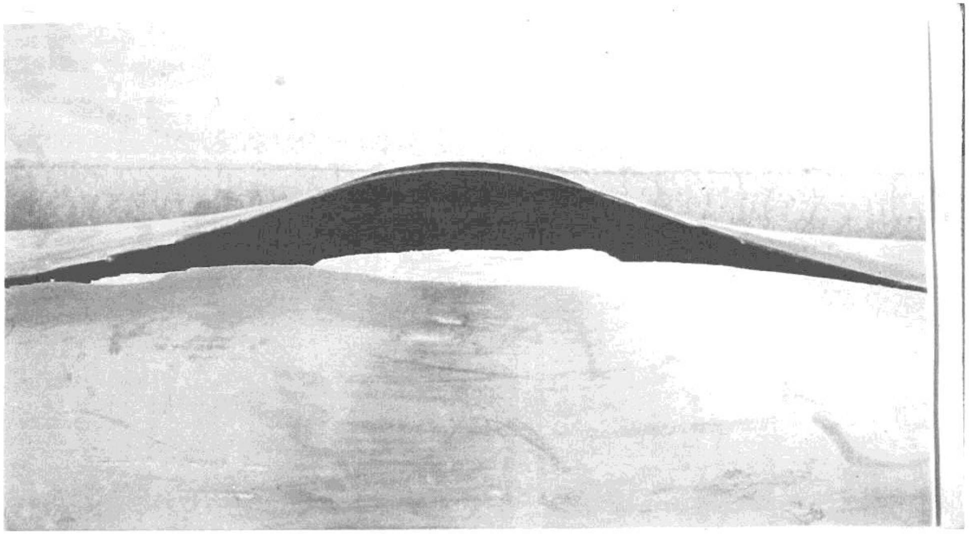
Will there be any test failures?

- Defects that may have arisen in service (e.g., corrosion, mechanical damage) may cause test breaks or leaks
- Test failures from original manufacturing flaws are not expected because the test pressures will be limited to the levels employed at the pipe mills at the time of manufacturing
- The manufacturing flaws should not have grown significantly in service because the mill test pressure to operating pressure ratio should have been at least 1.25 for pipe that was certified by the manufacturer

What happens when a defect fails during a hydrostatic test?

- If the flaw that fails is small, a leak may occur, and the test pressure will decay slowly
- If the flaw that fails is larger, a sudden rupture may occur releasing all of the pressure at once
- The fact that the test medium is water assures that length of the rupture will be short (a length of one to two pipe diameters in most cases) and that the released fluid will be non-flammable and non-toxic
- The hazardous zone associated with a rupture occurring during a hydrostatic test is limited to an area around the rupture site having less than a 50-foot radius

Pipeline leak during test to establish the effects of testing on a particular type of time-dependent degradation



Rupture that occurred during a separate pressurization of the same above-ground segment at a different location

Split along seam of pipe subjected to a hydrostatic test.
Arrows shows the location of a dent that had re-rounded during pressurization

Seam failed at pressure well in excess of pipeline operating pressure (seam anomaly that caused this failure was NOT a threat to the safety of the pipeline)

Overall View of the Piece Removed

Rupture in a liquid petroleum products pipeline during service, caused by a gouge previously created by excavating equipment

Close-Up View of Ruptured Region

Note that rupture in pipeline pressurized by liquid (rather than gas) does not propagate more than one or two pipe diameters, because fluid pressure release is almost instantaneous

Special case where there can be one exception to a one or two-diameter rupture during a hydrostatic test. The exception is associated with a rupture that initiates in the longitudinal seam of a particular kind of pipe. That pipe is low-frequency-electric-resistance-welded pipe, a kind of pipe that was manufactured prior to 1970. The characteristic of that kind of pipe that leads to longer splits during a hydrostatic test is generally low ductility of the seam region not seen in other types of line pipe manufactured at that time.

Pressure Reversals

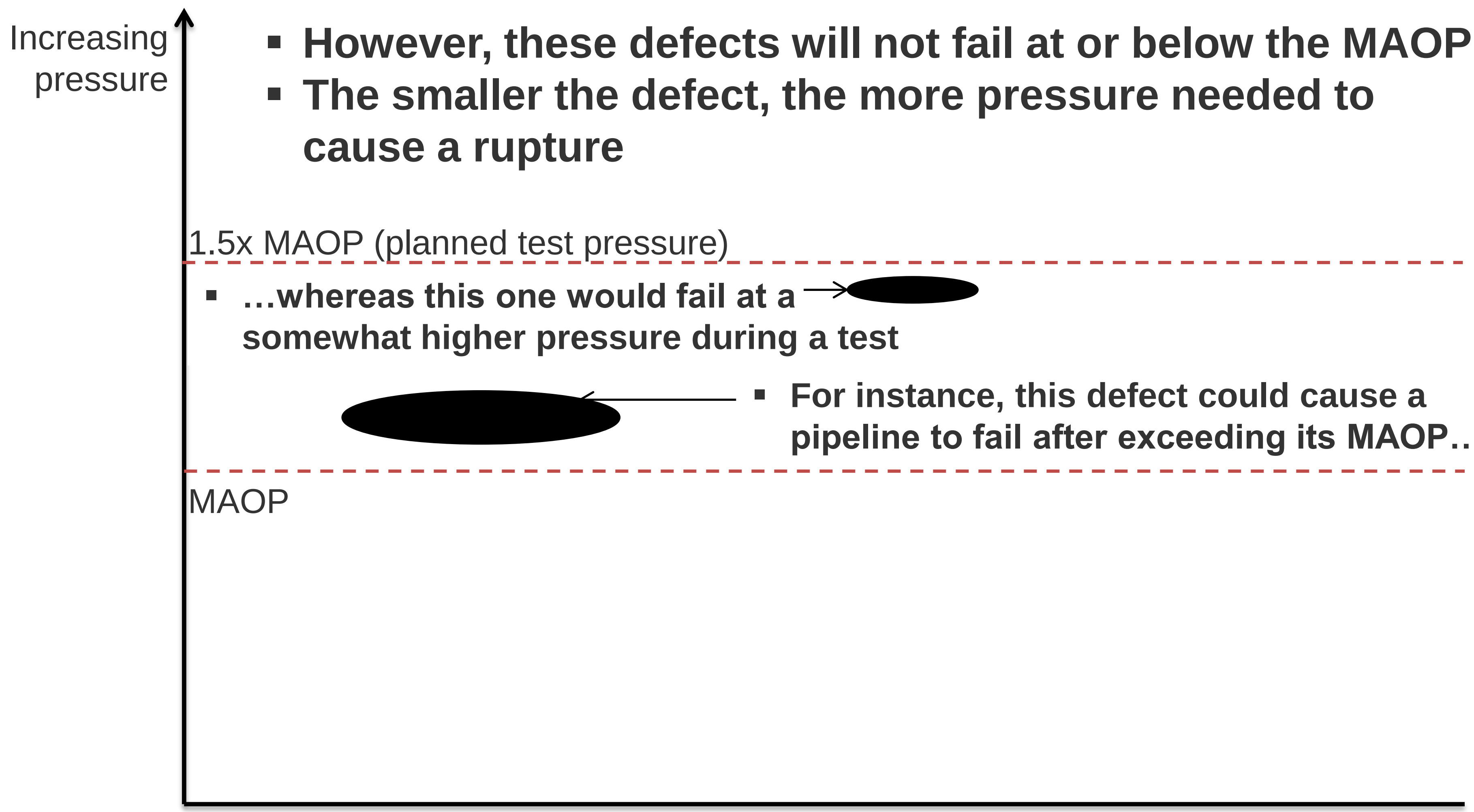
- A pressure reversal is defined as the reduction in failure pressure – the pressure at which a defect would cause pipeline failure – which is brought on by pressure cycling

- The mechanism of pressure reversals is based on:
  - Materials science and metallurgy principles – why it happens
  - Empirical data and laboratory/field work – how often it happens

- Well-understood scientific methods combined with real-life data drive the actual predictions of likelihood

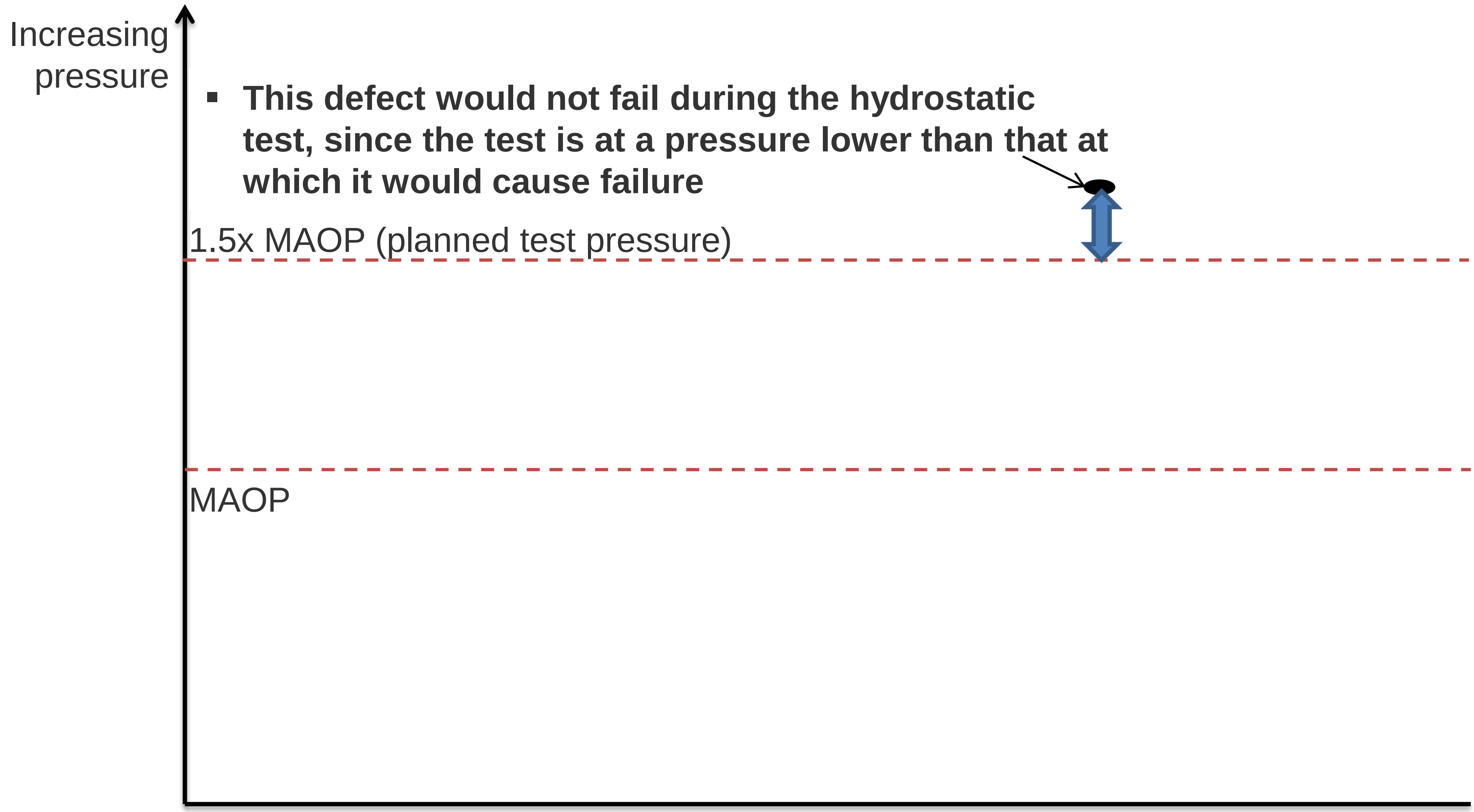
A pipeline operating safely at MAOP may have defects that could cause failure at higher pressure

- **However, these defects will not fail at or below the MAOP**
- **The smaller the defect, the more pressure needed to cause a rupture**



Defects shown are for illustration only and do not represent the actual shape or size of actual defects in pipelines

Still smaller defects would not cause failure, even at the elevated pressure during a hydrostatic test



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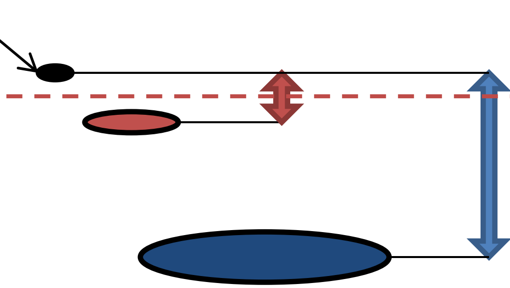
However, very small defects that would have failed just above the planned test pressure are subject to growth due to ductile tearing

Increasing pressure

- **These defects would not cause the test to fail, but because of the stresses caused by pressure cycling, could grow, and then later fail at a somewhat lower pressure**
- **This reduction in failure pressure is referred to as a pressure reversal**



1.5x MAOP (planned test pressure)

A pressure reversal of 1-3% has a probability of occurring in about 1 in 1000 pressurizations – however, this will not cause failure under normal operating conductions (i.e. below MAOP)

MAOP

A pressure reversal of 20% has a probability of about 1 in 800 million – and even this would require operating the pipeline above MAOP

Defects shown are for illustration only and do not represent the actual shape or size of actual defects in pipelines

Pressure Reversal Conclusions

- Hydrostatic pressure testing at 1.5x MAOP provides a safe means of establishing pipeline safety while providing enough margin to minimize the likelihood of subsequent pipeline failure
- The likelihood of a pressure reversal is essentially nil if a pipeline segment has no failures during its hydrostatic pressure test

Commissioner Mark Ferron

Commissioner Mike Florio

Commissioner Timothy A. Simon

QUESTIONS FROM COMMISSIONERS

Robert Gorham

Division Chief, Pipeline Safety

PERSPECTIVE FROM OFFICE OF STATE FIRE MARSHALL

Hydrostatic Testing

A Perspective by
the Office of the
State Fire Marshal
May 6, 2011

By
Bob Gorham
Division Chief
Pipeline Safety

Program Background

- Established by the Elder Pipeline Safety Act of 1981
- Certified intrastate Agent for U.S.DOT since 1984
- Certified interstate Agent for U.S.DOT since 1987
- Currently regulating 4500 miles of intrastate hazardous liquid pipeline
- Currently regulating 1200 miles of interstate hazardous liquid pipeline
- 46 intrastate operators
- 9 interstate operators
- 750 separate pipelines

Hazardous Liquid Pipeline Hydrotesting Requirements

Beginning in 1984

- All intrastate pipelines over 10 years of age must be periodically hydrotested or internally inspected at intervals not to exceed 5 years.
- Frequency can vary:
  - Annually if pipeline has no pressure limiting device
  - Every 2 years if leak history puts it on a “higher risk” classification
  - Every 3 years if pipeline has no effective cathodic protection
- Federal Integrity Management regulations now require all hazardous liquid pipelines to be inspected or tested not to exceed 68 months.)
- Over 3,000 hydrostatic tests have been conducted under this program

General Hydrotest Requirements

- Must notify SFM and local fire jurisdiction 3 days prior to test.
- Must use one of SFM approved independent testing firms to witness test.
- Test results to be submitted within 30 days to SFM for review.
- Leaks which occur during test must be immediately reported to the local fire department and Cal EMA
- Water must be used as a test medium unless a waiver is granted by SFM and U.S. DOT.

Length of test period

- 8 Hours - 4 hours@125% of Maximum Operating Pressure (MOP) plus 4 additional hours @110% of MOP
  - Newly constructed pipelines and pipelines where any segment is not entirely visible
  - Pipelines tested per DOT Integrity Management Program

- 4 Hours @ 125% of Maximum Operating Pressure
  - Pipelines where each segment under test is entirely visible (Pre-Tested Pipe)
  - Pipelines tested solely for CA Government Code

Effectiveness of Testing Program

- 1985 – 28 leaks occurred on hazardous liquid pipelines due to corrosion or weld failure.
- 2010 – Only one leak occurred on hazardous liquid pipelines due to corrosion

Observations

- California was the first program in the country to require pipelines to be periodically pressure tested or internally inspected.
- Federal Integrity regulations requiring periodic testing occurred 17 years later.
- California’s hazardous liquid testing program is mature as most pipelines have been tested 5-6 times over the past 27 years.
- Leak rates are at an all time low.
- When hydrotesting began in 1984, test leaks were common as corrosion pits that grew over time failed. As time went on, these were less frequent.
- Operators either had to test more frequently (i.e. to get ahead of the corrosion rate) or eventually abandon the line due to high maintenance costs.
- Approximately 60% of the pipelines are smart pigable.
- Smartpigging is the preferred inspection and test method.

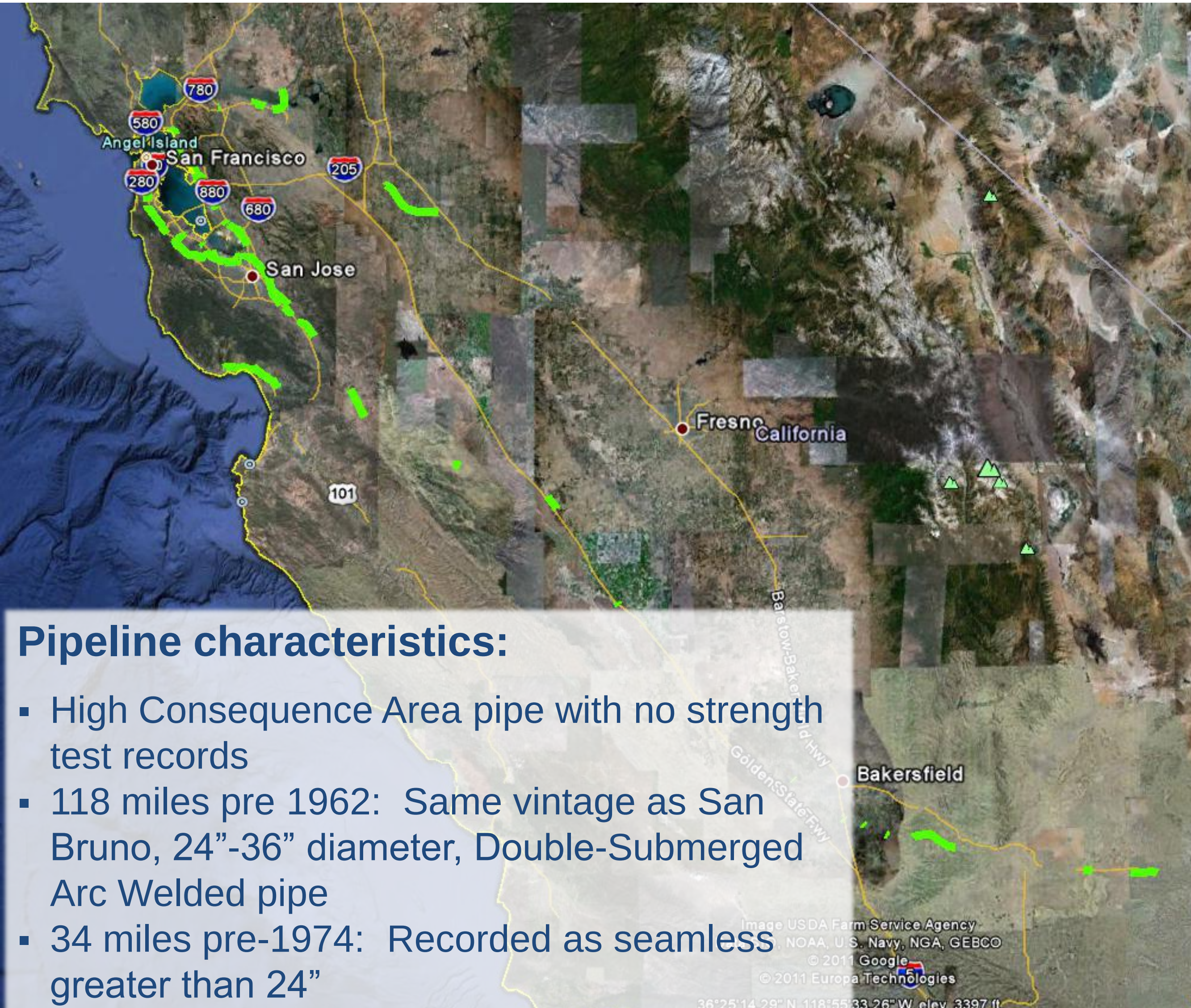
Questions?

Benjamin Campbell, P.E.

Pacific Gas and Electric Company

DETAILS OF PG&E’S TESTING PROGRAM

PG&E Plans to test 95 segments spanning over 150 miles of transmission pipeline in 2011

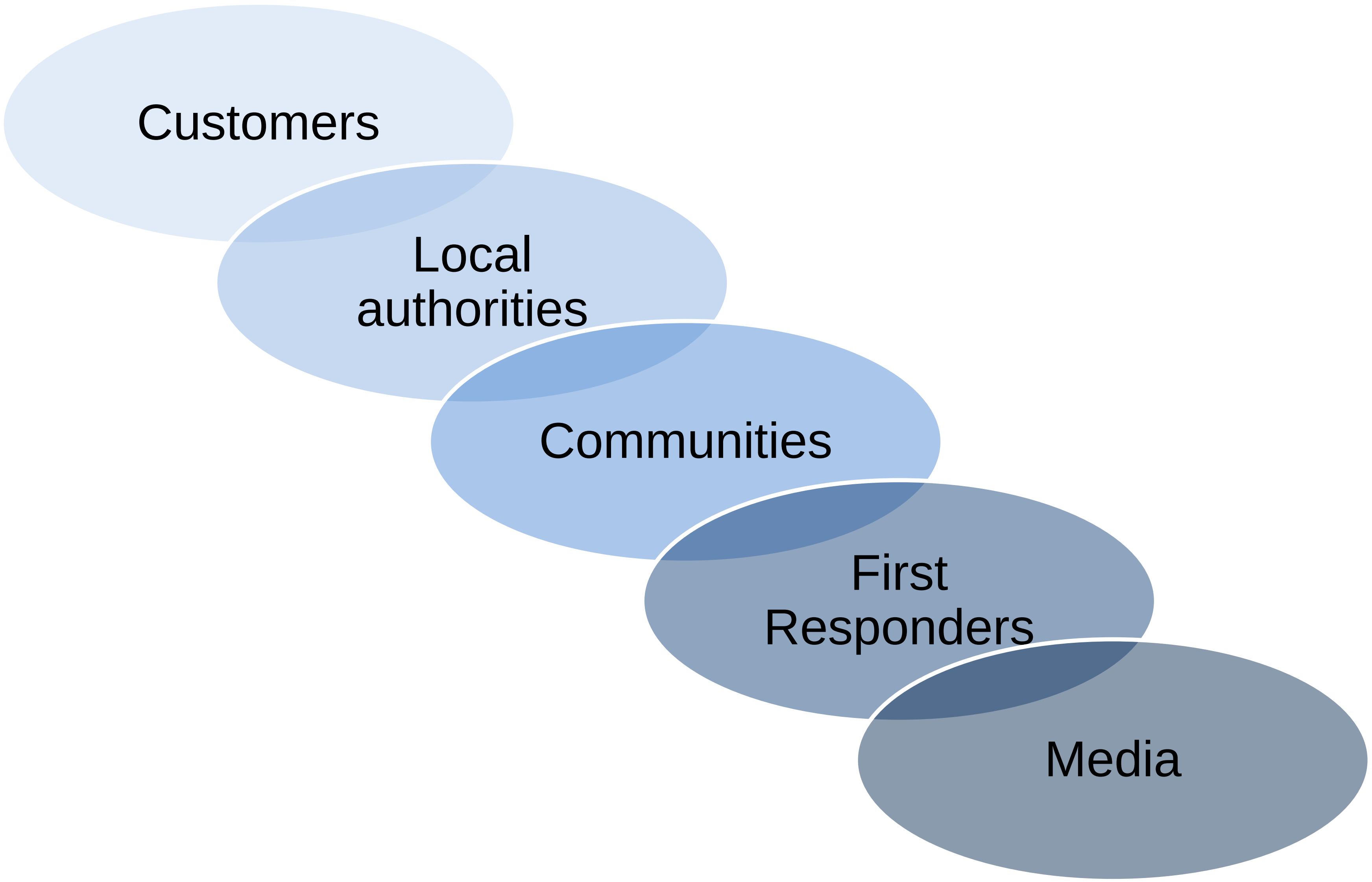


County	Number of segments
Santa Clara	24
Alameda	18
San Bernardino	13
San Mateo	11
Kern	8
Contra Costa	6
San Benito	5
Santa Cruz	4
Kings	3
San Francisco	3
Fresno	1
Stanislaus	1
Sonoma	1

Pipeline characteristics:

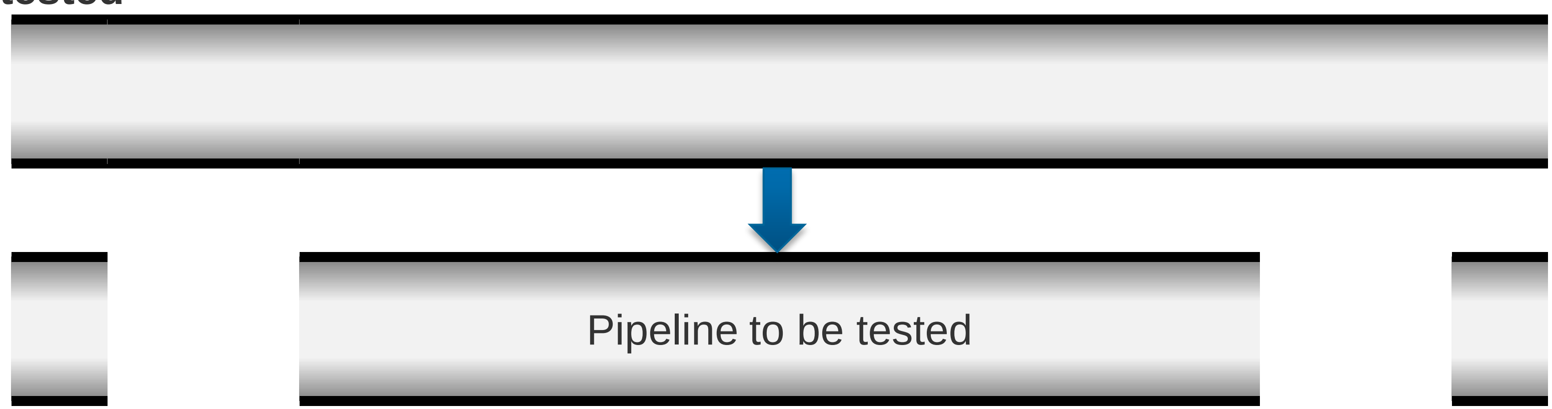
- High Consequence Area pipe with no strength test records
- 118 miles pre 1962: Same vintage as San Bruno, 24"-36" diameter, Double-Submerged Arc Welded pipe
- 34 miles pre-1974: Recorded as seamless greater than 24"

Prior to any hydrostatic testing work, PG&E reaches out to and engages local stakeholders

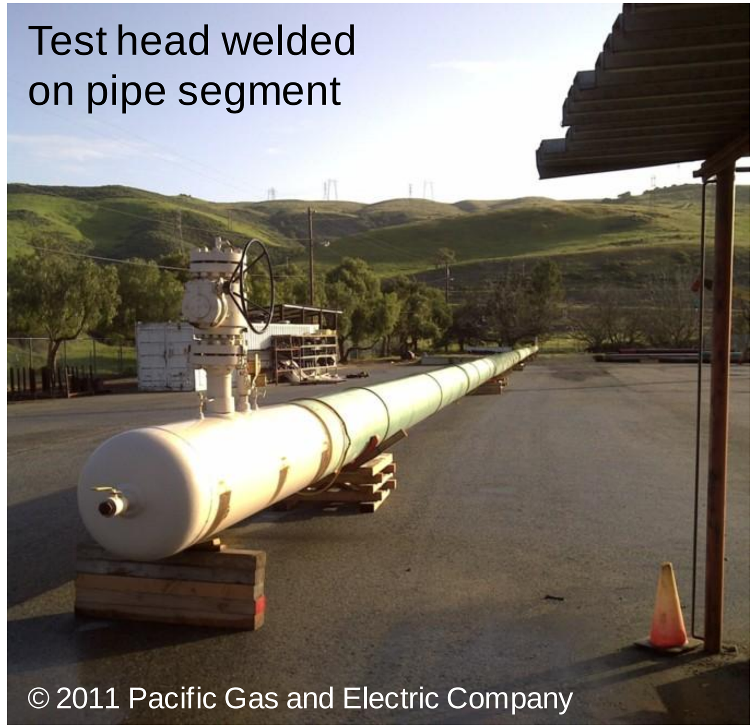


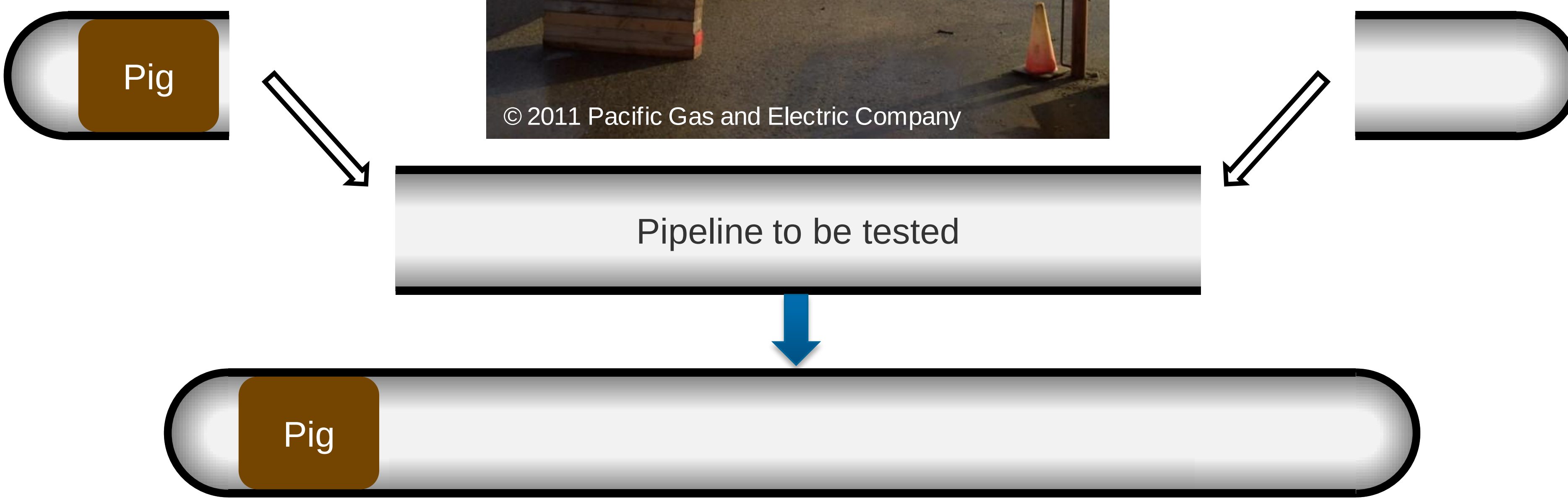
Taking a pipeline out of service is the first step in conducting a hydrostatic test

- The pipeline segment is vented of gas (commonly known as a blowdown)
- Residents in potentially impacted communities are notified by phone prior to venting
- Sections of pipe are then removed to isolate the segment to be tested

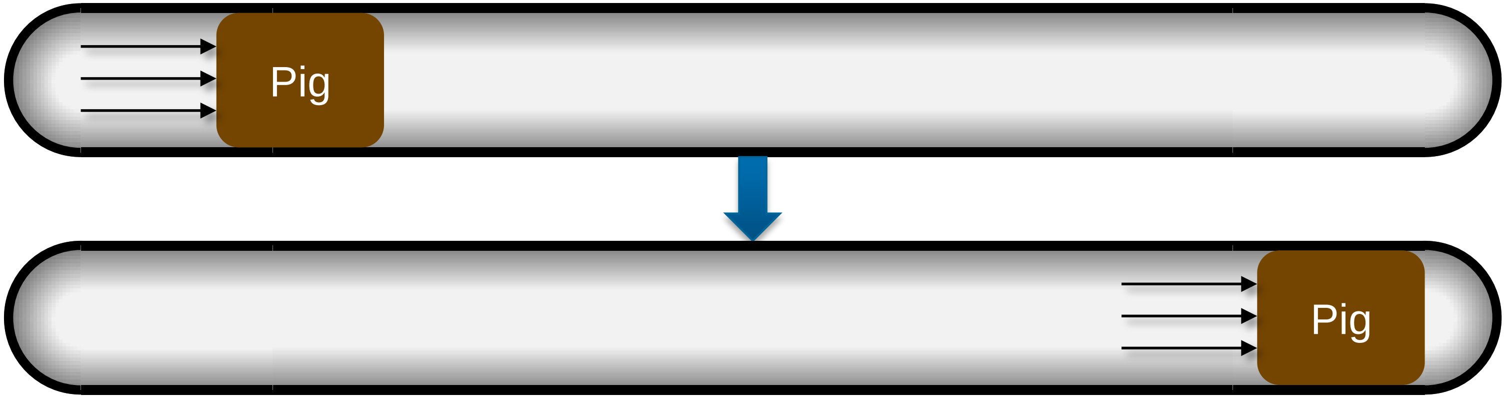


Next, two test heads are welded on; one of which has a “pig” installed



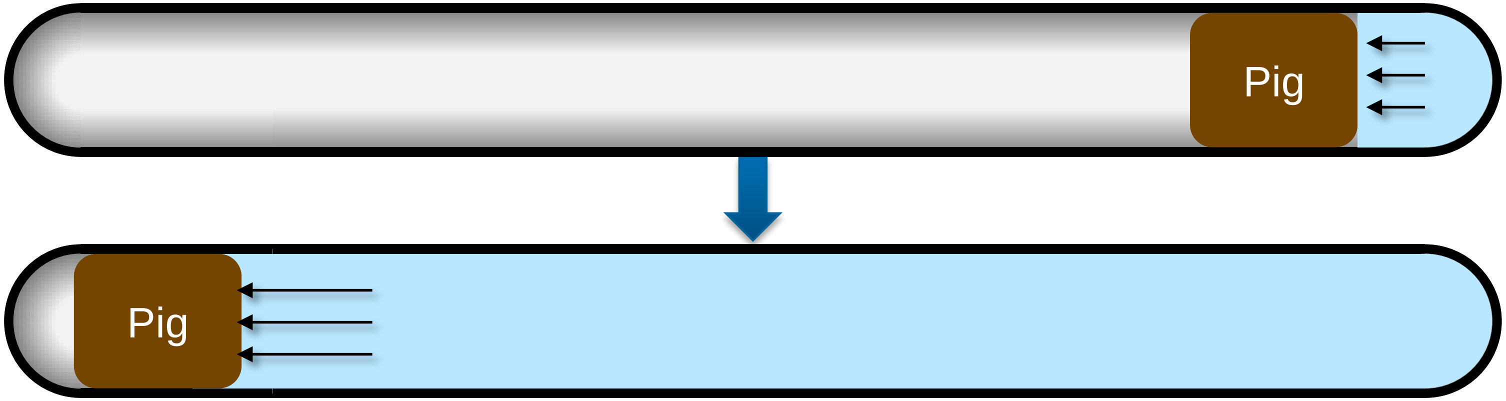


The pig is pushed through the test segment with air, removing residual oil and cleaning the pipe



The test segment is then filled with water

Irrigation pump and temporary water supply line.



The segment is pressurized and held at the test pressure for the duration of the test

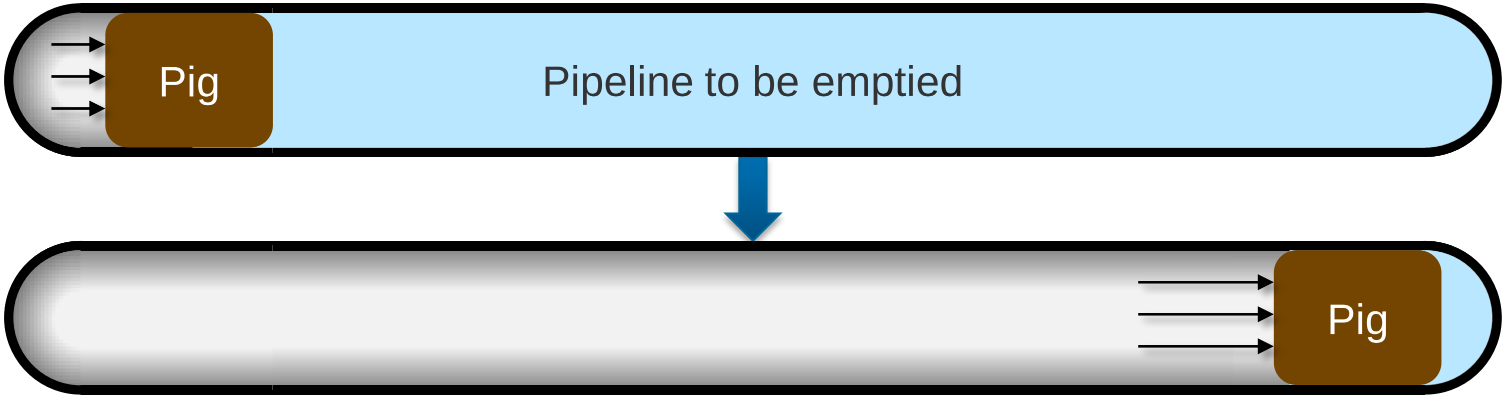
- Before the test begins, residents in the vicinity of the test segment are notified by phone of the test
- Those premises directly impacted by test equipment are also canvassed in person
- If feasible during the test, media, and where requested, regulatory and government officials are invited to observe the proceedings at the site
- The test is validated real-time by an independent third party (Bureau Veritas)

Monitoring an ongoing hydrostatic pressure test

To empty the pipe of water, the pig is once again pushed through using compressed air

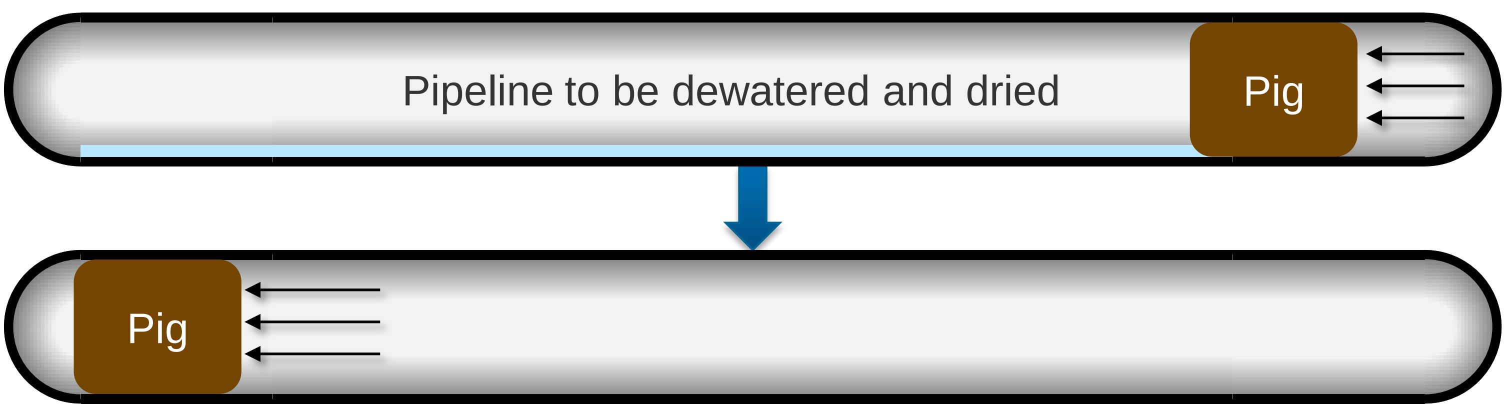
- Used water is purified and tested prior to disposal
- Where feasible, test water will be re-used for more than one test segment

Water disposal in a drainage/irrigation canal

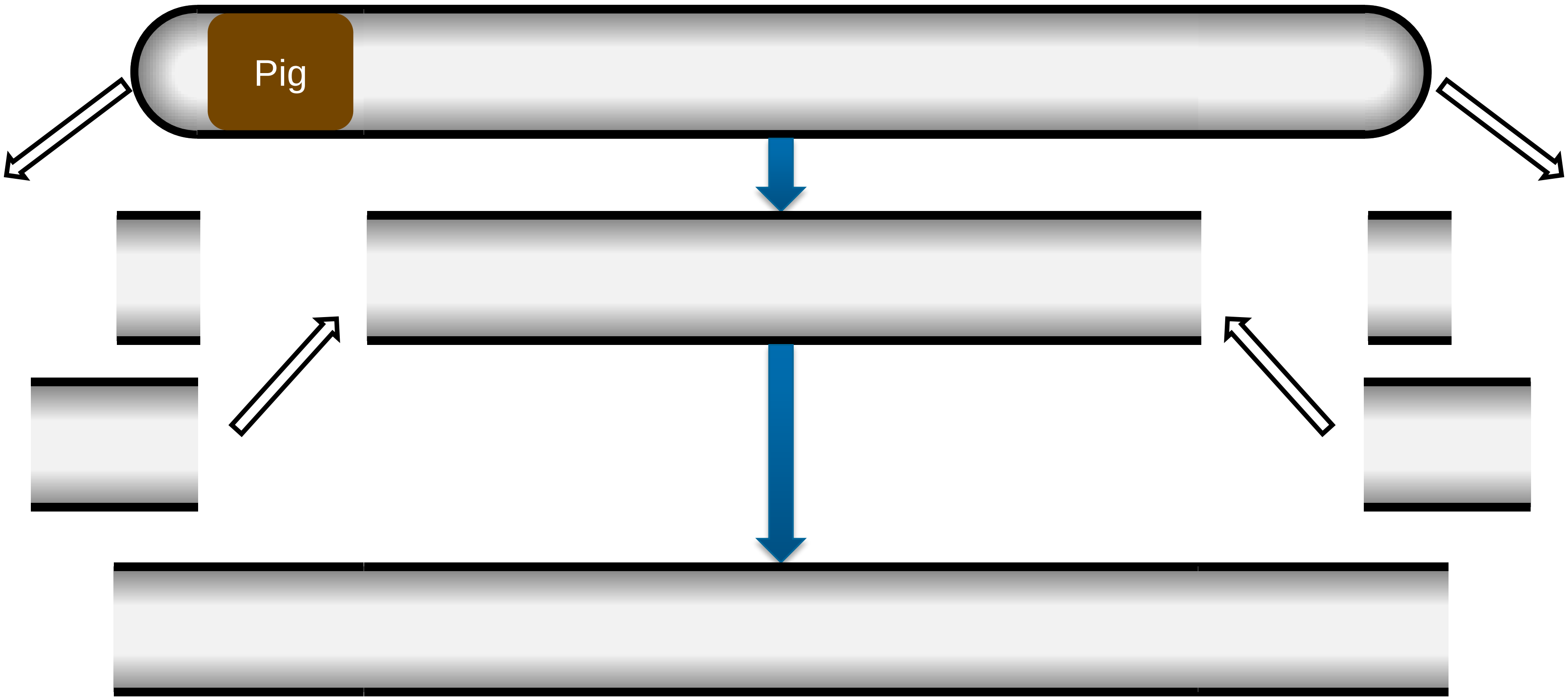


The pig is then pushed back to remove residual water and to dry the test segment

High pressure, high volume air compressors used to clean, de-water and dry pipeline



Finally, the test heads are removed, the segment is tied back in, and the pipeline is returned to service



- **Once the pipeline is tied in, the results of the test are communicated to customers and other stakeholders**

PG&E builds risk mitigation into its procedures; a few examples are listed below

#	Risk Description	Mitigation Strategy
1	Property damage from a water release during a test	▪ Set target test pressure below the mill test of the pipe – Minimum of 1.5 times MOP ▪ Coordinate with and prepare community ▪ Cordon off areas around the pipe during test
2	Internal corrosion from putting water in pipe during test	▪ Use compressed air to dry pipe after test ▪ Use potable water to prevent bacteria ▪ Cut off services and valve off regulators from transmission line to keep water from customers
3	Contamination from water used during test	▪ Clean pipe prior to adding water and dispose as hazardous waste ▪ Filter water after test while water flows into storage tanks ▪ Test stored water and if meets permit criteria –release water into sanitary sewer for treatment at waste water plant
4	Customer outage when pipeline is taken out of service for the pressure test	▪ Plan pressure tests during low demand time periods ▪ Plan operation to serve impacted area with alternative pipeline ▪ Use compressed gas or LNG supplies when alternative source is unavailable
5	High visibility in local community and media	▪ Develop and deploy, in advance of testing, a multi-channel customer, community, government, first responder and media outreach effort

PG&E's Approach to Managing Risk

- **Physical Risk (e.g. potential damage to property, contaminated water)**
  - Emergency response plan set up for individual tests
  - Site-specific safety plans
  - Clearly defined roles and responsibilities

- **Operational Risk (e.g. service outages)**
  - Operational adjustments to maintain normal service during tests
  - Risk management and contingency plans in place
  - Employees and contractors prepared to support various scenarios

- **Schedule Risk (delay to a test segment)**
  - Test schedule developed to ensure PG&E's ability to deliver gas service
  - Test schedule accounts for test segment characteristics (e.g., engineering difficulty, long lead time materials, encroachment permits, environmental permits etc.)

PG&E has taken action to fully minimize safety and operational risks.

Sunil Shori
Consumer Protection & Safety Division, CPUC

ANALYSIS OF PG&E’S HYDROSTATIC TESTING PROGRAM

Background

- Hydro-testing is not a new requirement and it has been used for decades
- All new pipelines installed have been required to be pressure tested since July 1, 1961, which was the effective date of General Order 112
- More stringent pressure tests were codified beginning with the federal standards enacted through the Natural Gas Pipeline Safety Act of in 1968
- The current regulations also limit the maximum hoop stress a segment can experience if the test medium is a compressible fluid (i.e., air, nitrogen, natural gas, etc.) to:
  - Class 1 -- 80% Specified Minimum Yield Strength (SMYS) in all cases
  - Class 2 -- 30% SMYS for natural gas – 75% SMYS for air or inert gas
  - Class 3 -- 30% SMYS for natural gas – 50% SMYS for air or inert gas
  - Class 4 – 30% SMYS for natural gas – 40% SMYS for air or inert gas

Current regulations require that:

- Lines at hoop stress of 30% or more of Specified Minimum Yield Strength (SMYS) are required to be held at the test pressure for 8 hours
- Lines at hoop stress under 30% SMYS are required to be held at the test pressure for 1 hour
- PG&E’s hydro-static testing will require all lines be held at the test pressure for 8 hours

What CPSD engineers have been doing in regards to upcoming hydro-tests?

- Meeting with PG&E's technical staff regarding the company's efforts related to pipeline data validation;
- Reviewed the methodology being used to derive MAOP's for segments lacking data
- CPSD pipeline safety engineers have reviewed PG&E's Hydro-testing Program
  - Public notification process and patrol of the area during the hydro-static test
  - The hydro-static test procedure
  - The documentation of data to be obtained from the excavation as well as the hydro-test itself
  - The documentation, testing, and retention of pipeline facility material samples, as well as any pipeline liquids obtained through the testing process
  - The quality assurance process in place to oversee all aspects of the testing beginning with data gathering to placing the tested segment back into service at an MAOP based on an actual strength test

Going forward CPSD will continue conducting field monitoring of activity related to:

- On-going transmission pipeline system integrity excavations
- Data gathering related to deriving MAOP of pipeline systems
- Hydro-tests which are being performed in order confirm they are being conducted to procedure and to recommend any improvements that may be warranted

Commissioner Mike Florio

Commissioner Mark Ferron

Commissioner Timothy A. Simon

QUESTIONS FROM COMMISSIONERS

Jess Brown, Pacific Gas and Electric Company

WHAT CAN THE PUBLIC EXPECT?

Outreach Objectives

Ensure customers, communities and local government officials are well informed

Provide multiple ways for customers to get answers to their questions

Initiate proactive outreach well ahead of visible PG&E onsite presence (no surprises)

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Tools to Achieve Outreach Objectives

Proactive

- Pre- and Post-construction ***letters*** with fact sheets
- Door-to-door ***canvassing*** with door hangers for customers closest to visible construction activity
- ***Calls*** to customers prior to key project events (e.g., venting, testing)

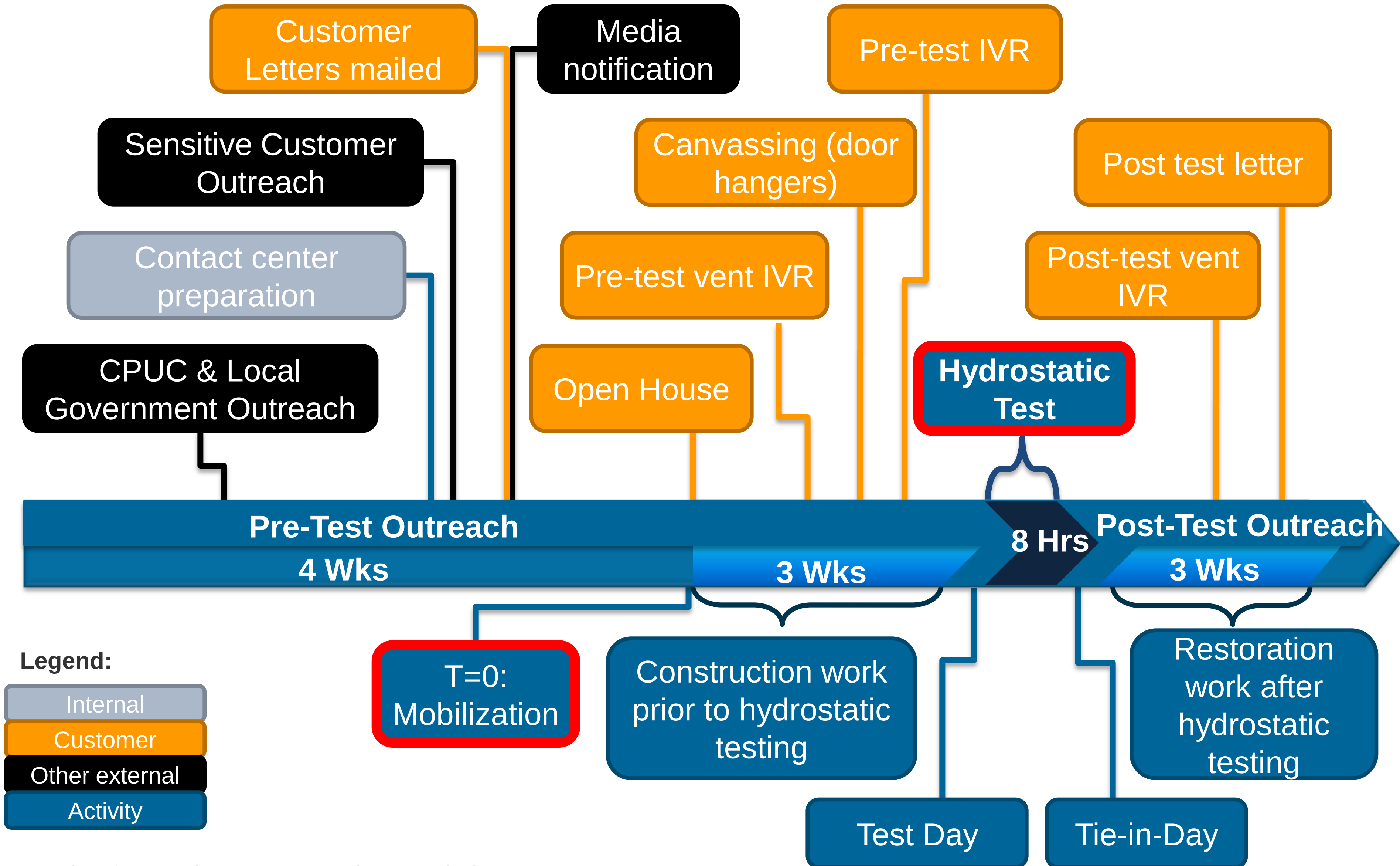
Interactive

- Neighborhood project ***open houses***
- ***Tailored outreach*** to business and sensitive customers (e.g., schools, hospitals, places of assembly)
- Local ongoing ***government engagement*** and ***media notification***

Responsive

- ***Dedicated*** M-F 1-800 gas specialist phone line
- ***24/7*** PG&E contact center line
- Local PG&E ***contacts*** to address customer questions and concerns
- Project information on www.pge.com ***website***

Typical Hydrostatic Test Project Outreach Cadence



Note – time frames shown are approximate and will vary slightly for each test

Michelle Cooke

Interim Deputy Executive Director for Safety

QUESTIONS FROM THE PUBLIC